wherein said liquid crystal device performs white display utilizing birefringence of said liquid crystal when voltage is not applied thereto, and performs black display when driven by applying DC or AC voltage of 10 to 20 V, and birefringence of said liquid crystal device is nullified when said voltage is applied to said liquid crystal device.

Contd C1

NW LCD

REMARKS

Claims 1 and 3 are rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,634,229 to Amstutz et al., in view of U.S. Patent No. 5,548,423 to Natsunaga. Applicants respectfully point out that the name of U.S. Patent No. 5,548,423 is a typographical error, and in fact should be Matsunaga. This reference is hereafter referred to as "Matsunaga".

Regarding claim 1, the Examiner asserts that Amstutz et al. discloses an LCD apparatus having a pair of transparent substrates, each having parallel strips of electrode layers, a super twist nematic liquid crystal sandwiched between the pair of substrates, wherein the total twisted angle (ϕ) of liquid crystal molecules is between 180° and 360°; and a pair of polarizers disposed to the outside of the pair of substrates, wherein the polarizers having absorption axes that are inherently orthogonal to each other and the absorption axes inherently being angled 45° with respect to a direction of the orientation or liquid crystal molecules in an intermediate portion in a direction of thickness of the liquid crystal layer (i.e., $\phi = 190°$, $\beta = 40°$ and $\beta + \gamma = 190°$).

Amstutz et al. does not disclose that the LCD can be driven by applying a voltage of 10 to 20V. However, in Figure 9 the Examiner notes that Matsunaga discloses that the drive region can be in the range of V_L (3 to 5V) to V_M (30 to 40V), and such disclosed range in Matsunaga

makes possible the claimed range of 10V to 20V, and the Examiner notes that overlapping ranges are at least obvious.

Applicants have amended claim 1 to more distinctly claim the invention, and respectfully disagree with the rejection for the following reasons. Applicants respectfully submit that the cited references, even if combined, would not teach all the limitations of the claimed invention.

In the claimed invention, absorption axes of the polarizing plates are orthogonal to each other, and angles between the absorption axes and a direction in which intermediate liquid crystal molecules are oriented are determined. On the other hand, Amstutz et al. does not determine them at all.

In the claimed invention, an STN liquid crystal is adopted and directions of the absorption axes are determined. As a result, the occurrence of birefringence in the liquid crystal can be controlled, thereby realizing fine white display and fine black display.

That is, white display is performed utilizing birefringence when the voltage is OFF, and black display is performed in a state where the retardation value is zero when the voltage is ON in the invention, as described above. In a state utilizing birefringence, incident light goes into the panel at an angle relative to the liquid crystal molecules, and the outgoing light separated into an x-component and a y-component is observed. In the invention, the liquid crystal molecules are raised to be perpendicular to the substrates when the voltage is ON, and both the x-component and y-component become zero, thus black display can be performed in a state where retardation value is zero.

Contrarily, in Amstutz et al., black display when the voltage is ON is also performed utilizing birefringence. Accordingly, in this case, black can be realized only when light in all wavelengths is orthogonal to the polarization axis of the polarizer.

Further, in the claimed invention, voltage of 10 to 20 V is applied to the liquid crystal device. That is, as shown in Fig. 3 by a solid line 20, the transmittance can be reduced by applying the voltage of 10 to 20 V, thereby fine black display can be performed, in the invention.

However, Amstutz et al. does not disclose that. On the other hand, in Amstutz et al. the transmittance increases more by applying such a voltage, thus causing deterioration in contrast, as shown by a broken line 21 (prior art). This is because Amstutz et al. drives the device in a state utilizing birefringence in both the ON state and OFF state.

In this invention, white display is performed utilizing birefringence when the voltage is OFF. When the voltage is ON, the voltage of 10 to 20 V is applied to raise liquid crystal molecules to be perpendicular to the substrates, thereby the birefringence made to be zero, and the polarizing plates are disposed so that black display can be performed in such a state. By applying voltage in the present invention, the response is improved and black display with low transmittance is realized.

Applicants respectfully submit that the cited references, even if combined, would not teach all the limitations of the claimed invention. Therefore, Applicants respectfully submit that the liquid crystal shutter according to the invention is not obvious from the cited documents.

For at least the foregoing reasons, Applicants submit that the claimed invention distinguishes over the cited art and defines patentable subject matter. Favorable reconsideration is earnestly solicited.

Should the Examiner deem that any further action by Applicants would be desirable to place the application in condition for allowance, the Examiner is encouraged to telephone Applicants' undersigned attorney.

In the event that this paper is not timely filed, Applicants respectfully petition for an appropriate extension of time. The fees for such an extension or any other fees which may be due with respect to this paper, may be charged to Deposit Account No. **01-2340**.

Respectfully submitted,

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Enclosures: Version with Markings to Show Changes Made

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

1. (Three Times Amended) A liquid crystal shutter comprising:

a liquid crystal device including a nematic liquid crystal sealed in between a first transparent substrate and a second transparent substrate on whose inner surfaces are formed respective transparent electrodes, said liquid crystal device having a twisted angle of 190° to 260°; and

a pair of polarizing plates between which are sandwiched said first transparent substrate and said second transparent substrate, said polarizing plates having respective absorption axes which are orthogonal to each other, said absorption axes of said polarizing plates being angled within a range of ± 40° to ± 50° relative to a direction in which intermediate liquid crystal molecules are oriented, said direction indicating a direction of orientation of said liquid crystal in an intermediate portion in a direction of thickness of said liquid crystal device;

wherein said liquid crystal device performs white display utilizing birefringence of said liquid crystal when voltage is not applied thereto, and performs black display when [is] driven by applying DC or AC voltage of 10 to 20 V, and birefringence of said liquid crystal device is nullified when said voltage is applied to said liquid crystal device.

W $V = 0$
B $V \neq 0$